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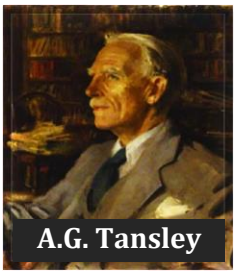
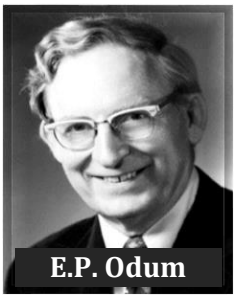
02 Ecosystem

1. Introduction :


A.G. Tansley


E.P. Odum

- **Definition –** Total living factor (biotic) and total non-living factor (abiotic) of the environment present in a particular area is called ecosystem.

A.G.Tansley – The term "ecosystem" first of all coined by **A.G. Tansley**.
According to Tansley – Ecosystem is symbol of structure and function of nature.
E.P. Odum – Father of ecosystem ecology.
According to E.P. Odum – Ecosystem is the smallest structural and functional unit of nature or environment.

- The boundaries of ecosystem are indistinct and have a overlapping character over each other.
- Ecosystem is the smallest structural and functional unit of nature or environment. It is a self regulatory and self sustaining unit.
- Ecosystem may be large or small. Single drop of water may be an ecosystem.
- Ecosystem may be temporary or permanent.
- Ecosystems are of two type - Natural or Artificial.

Natural Terrestrial Ecosystem – *e.g.* forest, grassland, tree, desert ecosystem

Natural Aquatic ecosystem – Aquatic ecosystem is again of two type:

- Lentic ecosystem → Stagnant water ***e.g.*** lake, pond, swamp.
- Lotic – Running fresh water ecosystem ***e.g.*** river

Artificial Ecosystem / Man made ecosystem
e.g. cropland, gardens, an aquarium etc.

Natural Terrestrial Ecosystem

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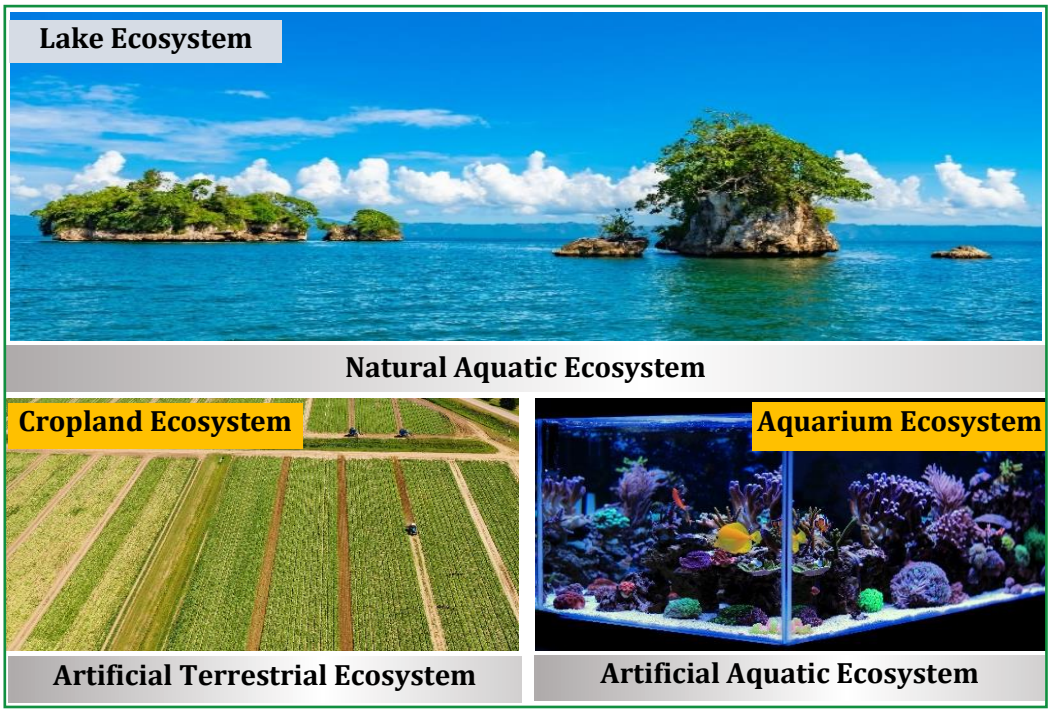

On the basis of size, types of ecosystem

- Mega ecosystem – Ocean/Sea
- Macroecosystem – Forest
- Microecosystem – Pond
- Nanoecosystem – Drop of water
- Every ecosystem is composed of two components – Biotic component & Abiotic component.
- Biotic component involve all livings (plant, animal and microbes) of ecosystem. Biotic component are mainly of two types - producer and consumer.
- Major abiotic components of ecosystems that lead to so much variation in the physical and chemical conditions of different habitats of ecosystems are temperature, water, light and soil.
- Major functional aspects of ecosystems are energy follow, nutrient cycle, decomposition and productivity.

2. Component and Functional Aspects of Ecosystems :

(A) Producers :

All the autotrophs of ecosystem are called producers. They prepare their own food. The green plants are the main producers. In the process of photosynthesis, producers absorb solar energy and convert it into chemical energy so producers are also called **transducers** or **converters**. Energy enters into the ecosystem through the producers. The **solar energy** is the only ultimate source of energy in ecosystem. This energy is available for the remaining living organisms.

In aquatic ecosystem : Floating plants called **phytoplankton** are the major autotrophs.

(B) Consumer :

All the heterotrophs of the ecosystem are known as consumers. They directly (herbivores) or indirectly (Carnivores) depend on the producers for food.

Types of consumer – Macroconsumers & Microconsumers

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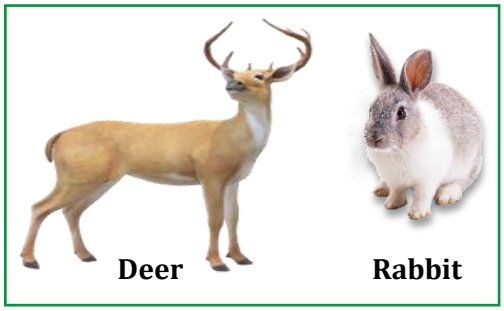
(i) **Macro consumers (Phagotrophs or holozoic) –** They digest their food inside the body i.e. first ingestion then digestion.

Macro consumers are of following type



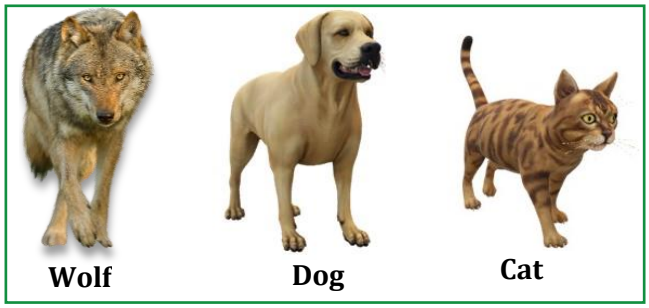
(a) **Primary consumer –** Such living organisms which obtain food directly from producers or plants are known as primary consumers.

e.g. Herbivores of ecosystem, cow, grazing cattle, Rabbit etc.

These are also known as **secondary producers** .

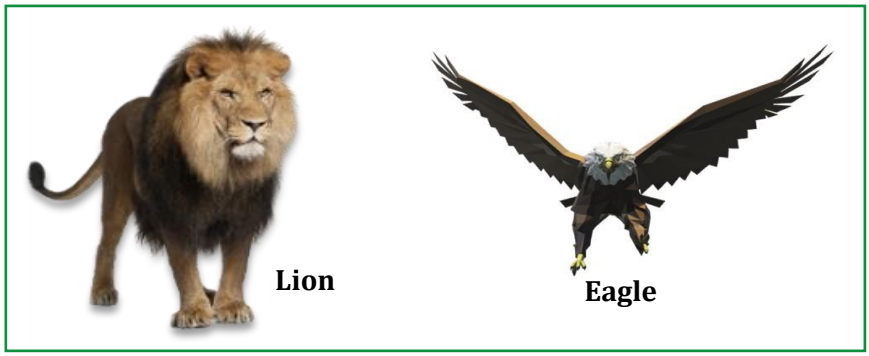
(b) **Secondary consumers or primary carnivores –** Animals which feed upon primary consumers and obtain food. Those carnivores which kill and eat the herbivores.

e.g. Dog, cat, snake etc.



(c) **Top Consumers –** Those animals which kill other animals and eat them, but they are not killed & eaten by other animal in the nature.

e.g. Lion, man, hawk, peacock etc.



(ii) **Micro Consumers/Decomposers or Saprotrophs/osmotrophs –**

Those living organisms which decompose the dead body of producers and consumers are known as decomposers or reducers or transformers or osmotrophs.

Note – The main decomposers in ecosystem are bacteria and fungi.

Decomposers play a significant role in mineral cycle. Decomposers are responsible for converting complex organic material of dead animals or plants into simpler organic matter through the process of decomposition and release mineral substances into the soil where these are reused by the producers, so that soil is considered as the best resource of minerals.

In bacteria and fungi, process of decomposition completely takes place outside the body. They release enzymes from their body on dead remains and decompose it into simpler organic substances and then absorb it so these are also called as **osmotrophs.**

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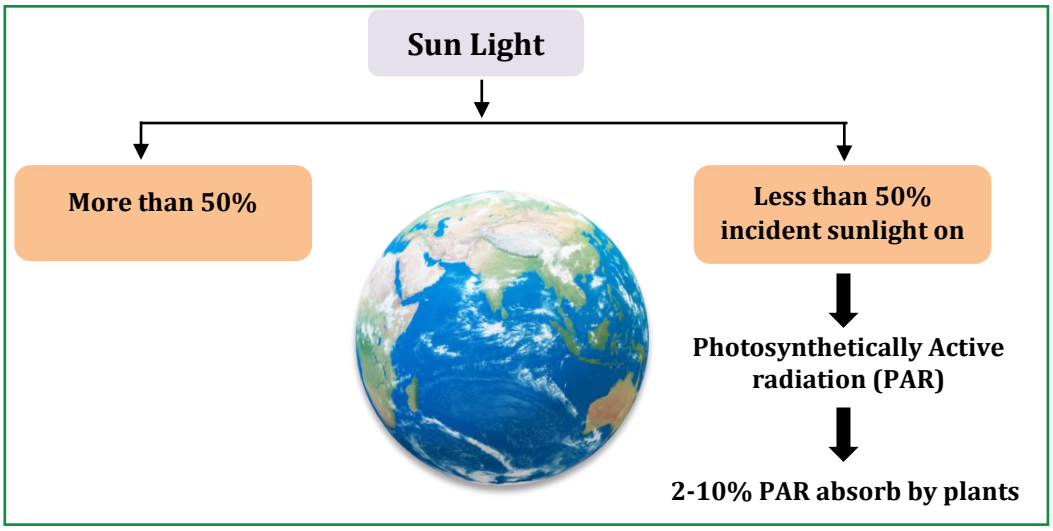
(C) Energy Flow :


Sun Light
More than 50%
Less than 50% incident sunlight on
Photosynthetically Active radiation (PAR)
2-10% PAR absorb by plants

The storage, expenditure, transformation of energy is based on two basic law of thermodynamics

First Law Of Thermodynamics (FLOT) : Energy is neither created nor destroyed but only transformed from one state to another state.

Second Law Of Thermodynamics (SLOT - the law of entropy) : The transfer of food energy from one to another organism leads to loss of energy as heat due to metabolic activity. **Further, ecosystems are not exempt from the Second Law of thermodynamics. They need a constant supply of energy to synthesise the molecules they require, to counteract the universal tendency toward increasing disorderliness.**

(D) Food Chain :

In ecosystem every organism depends on other organism for food material and all organism are (Plants, herbivores, carnivores) arranged in a series in which food energy is transferred through repeated eating and being eaten. It is called food chain. In food chain, energy flow is in the form of food.

In a food chain, food material or food energy transfer is from one trophic level to next trophic level. **Four trophic levels are present in the ecosystem, because level of energy decreases during the flow of energy from one trophic to the another trophic level.**

First trophic level	**[T_1]**	=	Producers
Second trophic level	**[T_2]**	=	Primary consumers
Third trophic Level	**[T_3]**	=	Secondary consumers
Fourth trophic level	**[T_4]**	=	Top consumers

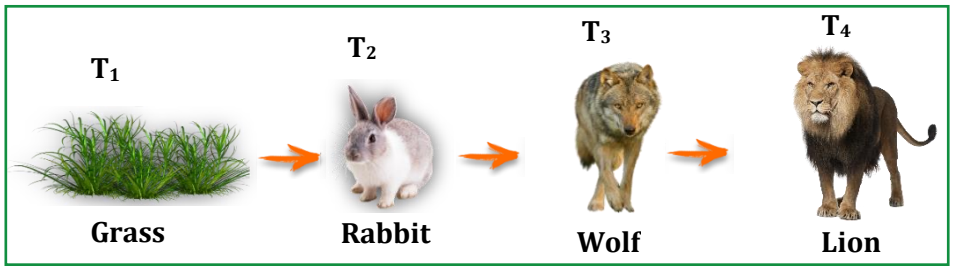
Note :

- There are **five trophic levels** found in highly complex ecosystem in which tertiary consumer is present in between the secondary consumers and top consumer. Then the fifth trophic level (T_5) is formed by the top consumer.
- In food chain energy flow is **unidirectional** (producers to top consumers)
- Shorter food chains will provide greater energy.
- Generally the decomposers (Bacteria and Fungi) are not included in the food chain.

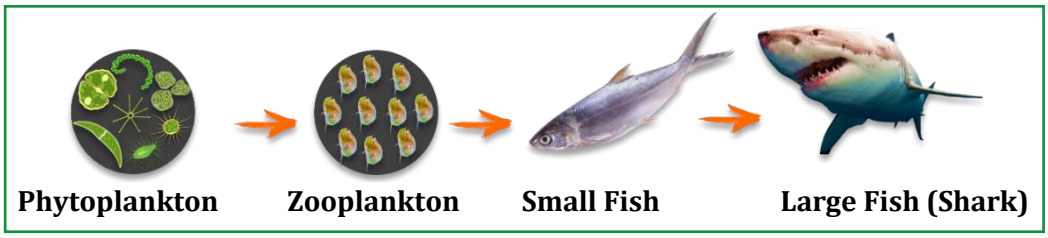
Type of food chains :- In nature three types of food chains are present

(i) **Grazing food chains or Predatory food chain –** Most of food chain in nature are of this type. This food chain begins with **producers** (plants) and in successive order it goes from **small organism to big organism**.

Terrestrial Ecosystem :-

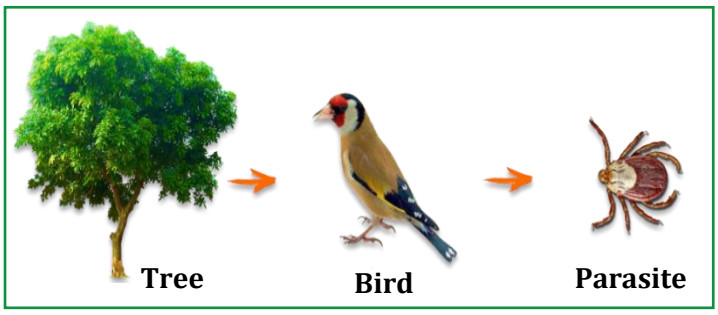


Aquatic Ecosystem



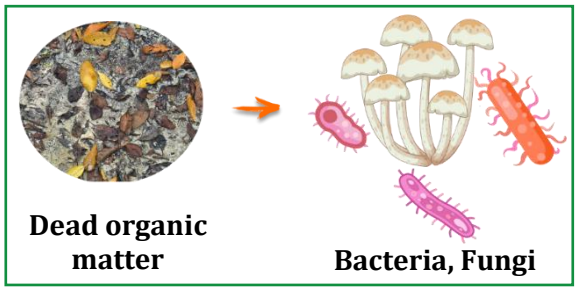
(ii) **Parasitic food chain –** This food chain also starts from **producers** but in successive order it goes from **big organism to the smaller organism**.

e.g. **Tree ecosystem –**



Note : Both above food chains are directly dependent on **solar radiation** (as a primary source of energy) and have **rapid energy flow**.

(iii) **Detritus food chain or Saprophytic food chain –** This food chain begins with decomposition of dead organic matter by **decomposers** so it is also known as saprophytic food chain. In this food chain primary consumers are bacteria and fungi.



Note :

- In detritus food chain **energy flow** is rather very slow yet **magnitude** of energy is great.
- In mangrove vegetation this food chain goes up to big organism.
  Dead mangroves leaves → Bacteria & fungi → Aphids, molluscs, crabs, nematodes → Small fishes → Tiger.
- In an aquatic ecosystem, **GFC (Grazing Food Chain)** is the major conduit (source) of energy flow. As against this, in a terrestrial ecosystem, a much larger energy flow through the **(DFC) Detritus food chain** than through the grazing food chain.

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Special point of Biotic Factor :

- In Sundarbans, Tigers feed on the fishes and crab in the absence of their natural prey.
- **Nutrient Immobilisation -** In the process of decomposition, some nutrients get tied up with the biomass of microbes and become temporarily unavailable to other organisms. Such incorporation of nutrient in living microbes (bacteria & fungi) is called **nutrient immobilisation.**
- In aquatic system **whale** is secondary consumer. It is an example of **filter feeder** because it feeds on plankton.
- **Plant parasites** are known as primary consumers while **animals parasites** (*E.coli* bacteria, *Entamoeba histolytica*, liver fluke, tapeworm) are known as secondary consumers.
- **All the insectivorous** plants play the double role i.e. producer as well as secondary consumer because they synthesise their own food through photosynthesis and they eat insects simultaneously.
- **Man, peacock, cockroach, crow, sparrow & Fish** are omnivores.
- Organisms which use **milk** or curd as food, are known as secondary consumer.

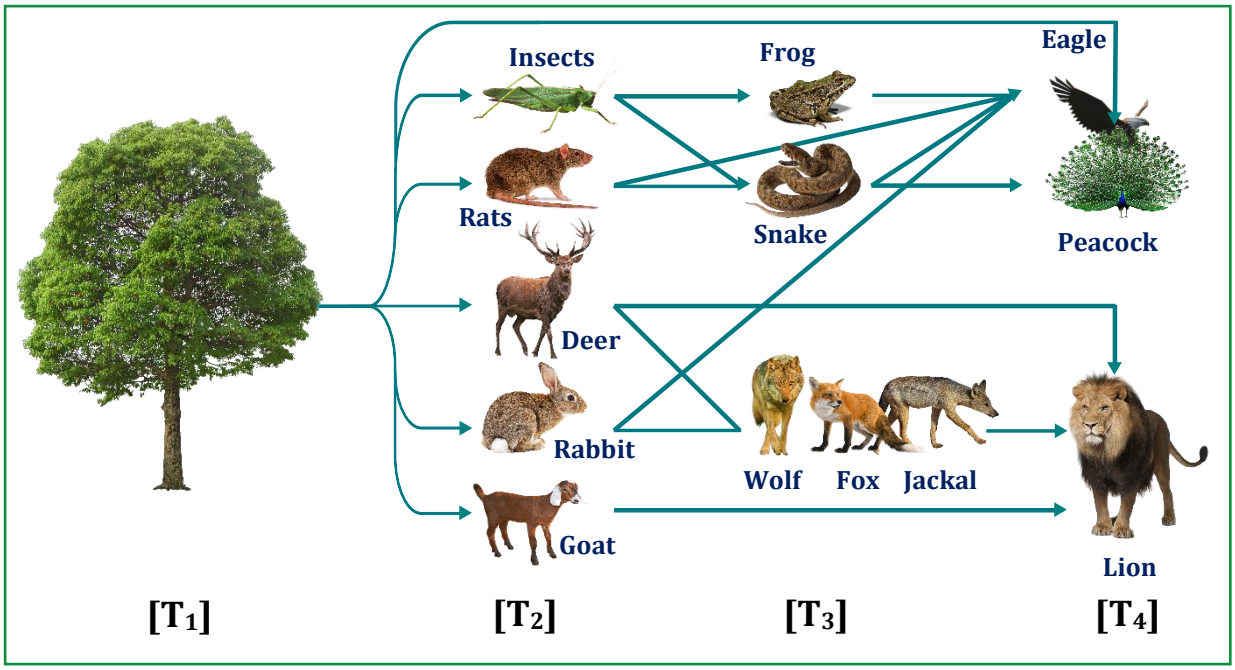
Note : **Inorganic materials** (CO_2 ,H_2O, Light), autotrophs (**Producers**) and **decomposers** are essential in ecosystem but, **macro consumers** are non-essential.

- Guild → Members of same trophic level.

(E) Food Web :

In big ecosystem many food chains are interlinked together on different trophic levels to form food web. In food web transfer of food energy is unidirectional but from many different alternative pathways.

In food web members of a particular trophic level obtain their food according to their choice and taste but that type of facility is not present in food chain. It means they have more than one option or alternative for getting food.



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As much as food web is complex that ecosystem is more permanent or stable, such type of ecosystem is not destroyed naturally and continues for long time. This ecosystem is not affected by loss of any organism of any particular trophic level. **Those ecosystems which have simple food web are not very stable** it means that they can be finished at any time, if there is a change in any particular trophic level.

(F) Homeostasis :

Ecosystem is a dynamic (functional) system because continuous interaction is going on in between biotic or abiotic components so ecosystem is present in an equilibrium position. Ecosystem is also self-maintainable and self-regulatory system, it means an ecosystem maintains a balance in between different trophic levels. Each trophic level controls the other trophic level in an ecosystem. If any change take place in any trophic level of ecosystem, the other trophic levels of this ecosystem may react according to it. So ecosystem always remain in equilibrium. This feature of system is known as **homeostasis**.

(G) Ecological Pyramids :

Graphical representation of ecological parameters at different trophic level in ecosystem is called pyramids. These parameters are Number, Biomass and Energy. First of all, pyramid was formed by **Charls Elton**; so we called it Eltonian pyramids.

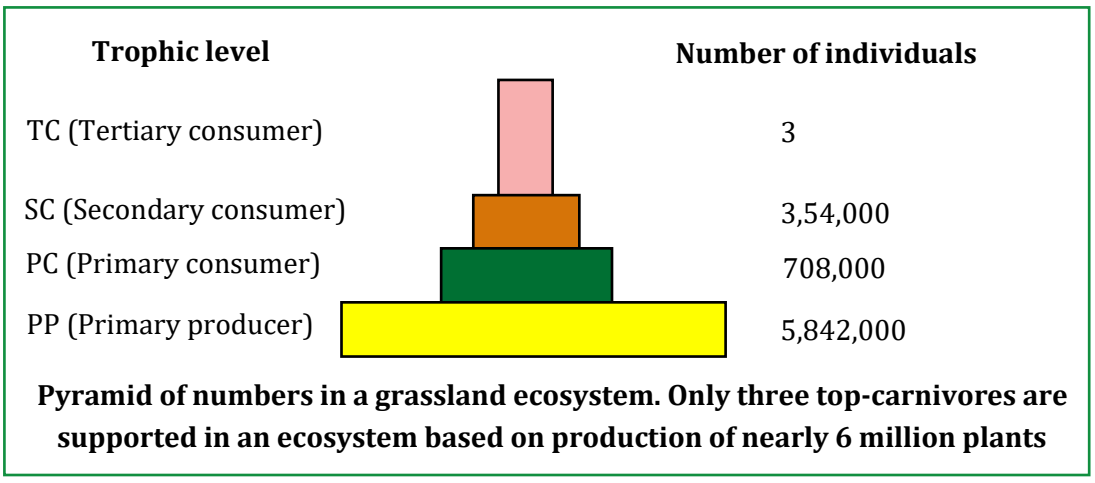
In pyramids basal, mid and top tiers show the parameter values for producer, herbivores and carnivores in the ecosystem.

These pyramid are of three types

(i) Pyramids of number
(ii) Pyramids of biomass
(ii) Pyramids of energy

(i) Pyramids of number –

In this type of pyramid the number of individual organisms in various trophic level is shown. These pyramids are mostly upright, because number of producers [T_1] is maximum and No. of herbivores and carnivores decrease towards apex or at successive trophic levels, such as Grassland ecosystem and aquatic ecosystem.



Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 million plants

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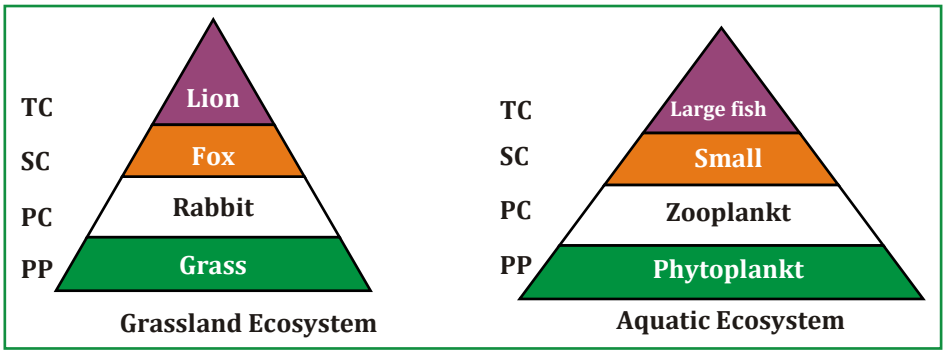
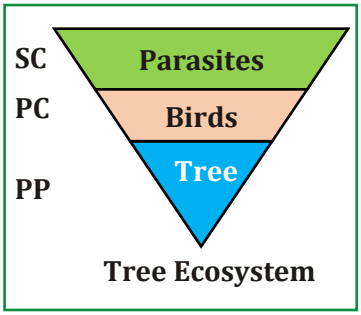


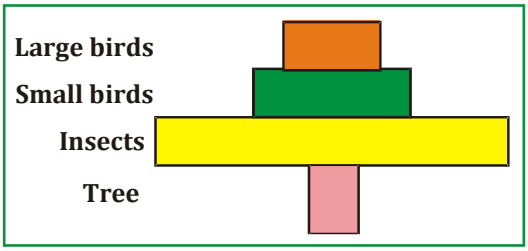
But in a tree ecosystem the pyramid of numbers is inverted. This is called parasitic ecosystem because birds (herbivores) depend on the tree (producer) and parasites (consumer) depend on birds, therefore with increase in the no. of trophic levels, the number of the organisms increases sequentially.



Note: Pyramid of number shows **biotic potential** of an ecosystem.

- Maximum number of producers are present in aquatic ecosystem. **The number of organisms at any trophic level depends upon the availability of organism which are used as food** on lower level so availability of food is main factor.
- If on a big tree, large number of insects feed followed by a number of small birds depending on the insects and large birds eating smaller birds.

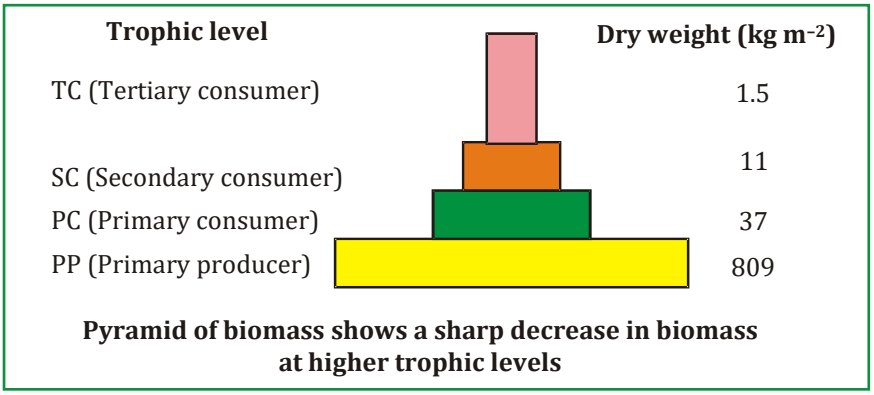
Shape of pyramid of number – spindle shape



(ii) Pyramid of Biomass –

Pyramids of biomass represent the total amount of biomass of each trophic level of ecosystem, mostly these pyramids are also upright (erect) ***e.g.*** (tree ecosystem), forest ecosystem.

Note : The pyramids of biomass show the **standing crop** of ecosystem.



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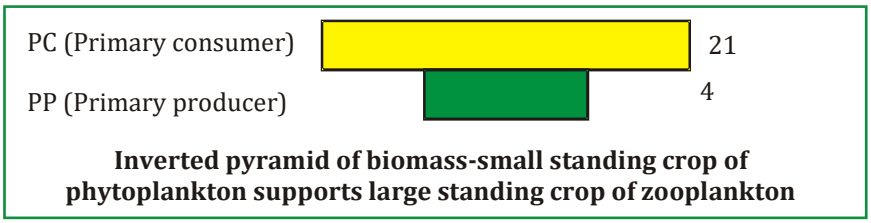
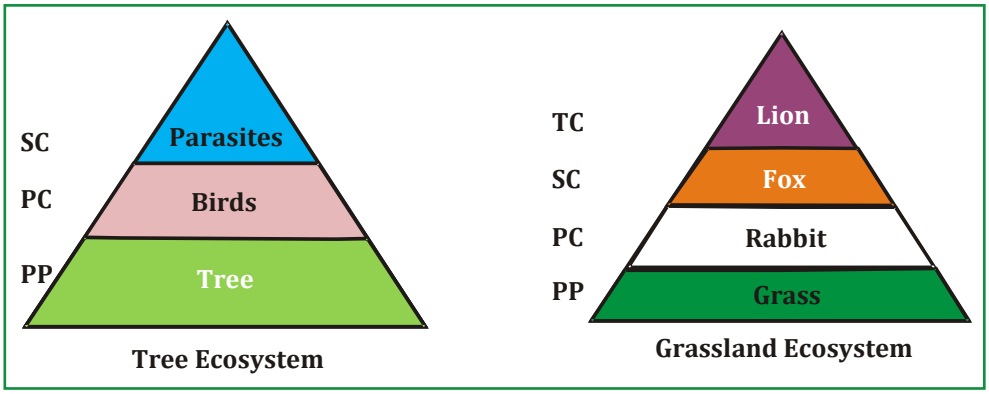
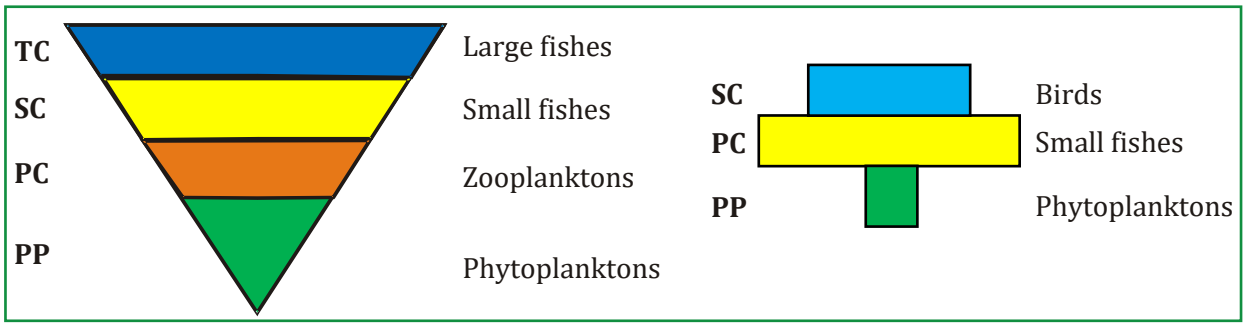


Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton



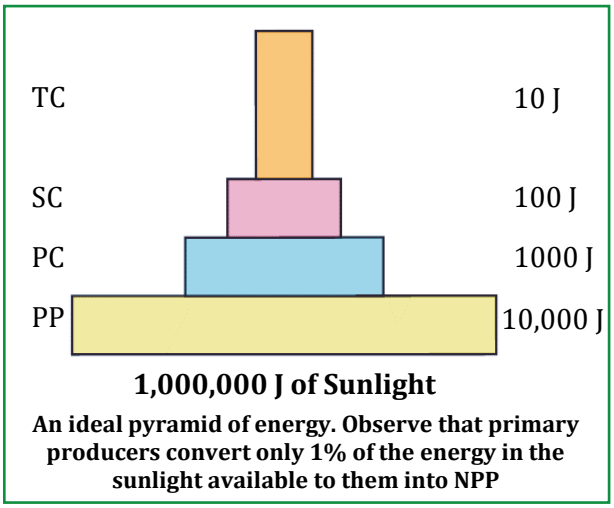
Pyramids of biomass in **aquatic ecosystem** is inverted because in it producers are micro-organism and their biomass is very less.



Note : Pyramid of biomass in lake ecosystem.

(iii) Pyramids of energy –

It represents amount of energy at different trophic levels, energy pyramids are always upright or erect because there is a gradual decrease in energy at successive trophic levels. According to the **10% law of Lindeman**, the 90% part of obtained energy of each organism is utilized in their various metabolic activities and heat and only 10% energy is transferred to the next trophic level. So 90% energy is lost at each trophic level, therefore **top consumers like lion etc. are ecologically weakest** but physically they are strong.



An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP

Note : Pyramids of energy represent the productivity of ecosystem as well as transfer of production in ecosystem.

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Limitations of Ecological Pyramids –

- It does not take into account (consider) the same species belonging to two or more trophic levels.
- It assumes a simple food chain, something that almost never exists in nature. It does not accommodate a food web.
- Saprophytes are not given any place.

Some Special point :

- **Standing crop –** Total amount of **living organic matter** present in particular area in particular time in an ecosystem is known as standing crop. It may be expressed in terms of weight per unit area.
- Biomass is the standing crop expressed in terms of weight (i.e. organism mass). Biomass is measured by **bombcalorimeter.**
- **Standing quality or Standing state** – Total amount of **inorganic substances** such as P, S, N, H present in particular area at a particular time in an ecosystem is known as standing state.

(H) Productivity :

There are two type of productivity present

(i) Primary productivity :

Primary production is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. It is expressed in terms of weight (g/m^2) or energy (Kcal m^{-2}). The rate of biomass production is called productivity. It is expressed in terms of g m^{-2} yr^{-1} or (Kcal m^{-2}) yr^{-1} to compare the productivity of different ecosystem.

It is of two types :

(a) Gross primary productivity (G.P.P.) : It is the total amount of energy fixed (organic food) in an ecosystem (in producers) in unit time is called G.P.P. including the organic matter used up in respiration during the measurement period. It is also known as total (Gross) photosynthesis. A considerable amount of GPP is utilised by plants in respiration.

(b) Net primary productivity (N.P.P.) : It is the amount of stored organic matter in plant tissues after respiratory utilisation

NPP = GPP – R (R = Respiration / Metabolic activities)

or

GPP = NPP + R

NPP is the available biomass for the consumption to heterotrophs.

(ii) Secondary productivity – Sec. productivity is the rate of formation of new organic matter by consumers.

Note: Net community productivity or Net productivity :

The rate of storage of organic matter not used by the heterotrophs

NCP = N.P.P. – HR (HR = Energy used by Heterotrophs)

During Succession net community productivity or annual yield decreases.

Some information's related to productivity :

- Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors availability of nutrients and photosynthetic capacity of plants. Therefore it varies in different type of ecosystem. The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of the organic matter, productivity of the ocean are only 55 billion tons.
- Among terrestrial ecosystems maximum productivity found in tropical rain forest.
- In water, least productive ecosystem is very deep lakes and highly productive ecosystem is coral reef.
- Limiting factor for productivity in ocean is nitrogen and in lake is phosphorus.

★ Golden Key Points ★

- The boundaries of ecosystem are indistinct and have a overlapping character over each other.
- Natural ecosystem show high stability as compare to artificial ecosystem due to high species diversity.
- During photosynthesis primary producers absorb solar energy and convert it into chemical energy so producers are also called transducer or converters.
- Decomposers play a significant role in mineral cycle so that presence of decomposers is essential for stability or existence of ecosystem.
- There are two basic function of ecosystem. (i) Energy flow, (ii) Nutrient cycling
- Ecosystem are not exempt from the second law of thermodynamics.
- Tertiary consumer is present in between the secondary consumer and top consumer.
- Generally the decomposers (Bacteria/Fungi) are not included in the food chain but when included then included as the last trophic level.
- Pyramid of number shows biotic potential of a ecosystem. Pyramid of biomass show the standing crop of ecosystem. Pyramid of energy represent the productivity of ecosystem.
- Net primary productivity (NPP) is the available biomass for the consumption to heterotrophs.

BEGINNER'S BOX-1

BIOTIC COMPONENT, FOOD CHAIN, FOOD WAVE, ECOLOGICAL PYRAMID, PRODUCTIVITY

1. Grass → Deer → Tiger
In this food chain, the biomass of grass is 1 tonne. The tiger biomass will be :
(1) 100 kg (2) 10 kg (3) 1 kg (4) 1000 kg

2. An ecosystem is a complete interaction of :
(1) Individual (2) Population
(3) Community and their soil condition (4) Community and their physical environment

3. What is correct for transducers :
(a) They converts solar energy into chemical energy
(b) They have first trophic level
(c) They are osmotrophs
(d) Those show nutrient immobilization
(1) b, c (2) a, b (3) c, d (4) a, d

4. Ecosystem resists change because its stage is :
(1) Imbalance (2) Homeostasis
(3) Deficient component (4) Affected by light

5. On Earth in per unit area maximum productivity occur in :
(1) Tropical rain forest (2) Ocean
(3) Temperate deciduous forest (4) Marsh

6. In which of the following ecosystem pyramids are always upright ?
(1) Tree ecosystem (2) Lake ecosystem
(3) Grass land ecosystem (4) All of above

7. On the basis of ecology which is not essential for self-sustaining ecosystem :
(1) Producer (2) Macro-consumers (3) Micro-consumers (4) All of above

8. Which of the following is not recycled in an ecosystem :
(1) Water (2) Carbon (3) Energy (4) Nitrogen

(I) Light :

- It is a complex physical environmental factor. Light is measured by luxmeter or photometer. It is a electromagnetic spectrum.
- **Solar Constant** – Solar radiation before entering the atmosphere carries energy at a constant rate i.e., 2 cal cm^{-2} min^{-1} known as the solar constant.
- In solar radiation wavelength (λ) of light or visible spectrum is 0.4 to 0.7 μm (400–700 nm) it is also called photosynthetically active radiation (PAR).
- The U. V. radiation distinguished in
  U. V. – C → (0.100 to 0.280 μm)
  U. V. – B → (0.280 to 0.320 μm)
  U. V. – A → (0.320 to 0.400 μm)

Albedo value – The ability of a surface to reflect the incoming radiation is called albedo value (AV) it is 80% for fresh snow, 20-30% for sand, 5-10% for the forest.

Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth. Of the incident solar radiation (ISR) less than 50 per cent of it is photosynthetically active radiation (PAR). Plants capture only 2-10 per cent of the PAR and this small amount of energy sustains the entire living world.

Many species of small plants (herbs and shrubs) growing in forests are adapted to photosynthesise optimally under very low light conditions because they are constantly overshadowed by tall, canopied trees. Many plants are also dependent on sunlight to meet their photoperiodic requirement for flowering. For many animals too, light is important in that they use the diurnal and seasonal variations in light intensity and duration (photoperiod) as cues for timing their foraging, reproductive and migratory activities. The availability of light on land is closely linked with that of temperature since the sun is the source for both. But, deep (>500m) in the oceans, the environment is perpetually dark and its inhabitants are not aware of the existence of a celestial source of energy called Sun. What, then is their source of energy?).

Hydrothermal vents – These are hot water springs in the deep ocean having high concentration of H2S. Chemosynthetic bacteria oxidizes H2S producing energy which is used for preparing their own food. Filter-Feeders (clams) eat these bacteria so that this food chain based on chemical energy.

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(J) Temperature :

- Temperature is measured by the thermometer and under water by thermistor.
- Temperature is the most ecologically relevant environmental factor.
- The average temperature on land varies seasonally, decreases progressively from the equator towards the poles and from plains to the mountain tops.
- It ranges from subzero levels in polar areas and high altitudes to >50°C in tropical deserts in summer.
- There are, however, unique habitats such as thermal springs and deep-sea hydrothermal vents where average temperatures exceed 100°C.
- It is general knowledge that mango trees do not and cannot grow in temperate countries like Canada and Germany, snow leopards are not found in Kerala forests and tuna fish are rarely caught beyond tropical latitudes in the ocean.
- Temperature affects the kinetics of enzymes and through it the basal metabolism, activity and other physiological functions of the organism.

(i) **Adaptation :** Adaptation is any attribute of the organism (morphological, physiological, behavioural) that enables the organism to survive and reproduce in its habitat.
Many adaptations have evolved over a long evolutionary time and are genetically fixed.

(a) **Morphological adaptations :** In Animals : Temperature affect the absolute size of an animal and its body parts.
Bergman's rule – Birds and mammals attain greater body size in cold region and lesser in warm region.
Allen's rule – Mammals from colder climates generally have shorter ears and limbs to minimise heat loss. (This is called the Allen's Rule.)
Heat loss or heat gain is a function of surface area. Since small animals have a larger surface area relative to their volume, they tend to lose body heat very fast when it is cold outside; then they have to expend much energy to generate body heat through metabolism. This is the main reason why very small animals are rarely found in polar regions.
In Plants – Some desert plants like Opuntia have no leaves. Leaves modified into spines to reduce transpiration the photosynthetic function is taken over by the flattened stems.

(b) **Physiological Adaptations :**

- In the polar seas aquatic mammals like seals have a thick layer of fat (blubber) below their skin that acts as an insulator and reduces loss of body heat.
- Many desert plants have a thick cuticle on their leaf surfaces and have their stomata arranged in deep pits to minimise water loss through transpiration. They also have a special photosynthetic pathway (CAM) that enables their stomata to remain closed during day time
- Anti freezing protein compounds allow the fishes in Antarctica region to remain active in sea water.
- Many xerophytes may accumulate proline (an amino acid) in their cells to maintain osmotic and water potential in their leaves.
- The heat shock protein (chaperonins) provide physiological adaptations to plants to high temperature. This protein help other protein to maintain their structure and avoid denaturation at high temperature.
- In the absence of an external source of water, the kangaroo rat in north American deserts is capable of meeting all its water requirements through its internal fat oxidation (in which water is a by product). It also has the ability to concentrate its urine so that minimal volume of water is used to remove excretory products.

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Acclimatisation – Acclimatisation is a gradual physiological adjustment of the organism to the slowly changing new environmental condition. If there is a shift in some environmental factor beyond the tolerance range of an organism the latter can come to the resting stage or migrate.
Some organisms posses adaptations that are physiological which allow them to respond quickly to a stressful situation. If we go high altitude place we experienced what is called altitude sickness. Its symptoms include nausea, fatigue and heart palpitations. This is because in the low atomospheric pressure of high altitudes, the body does not get enough oxygen. (Our body solve this problem - The body compensates low oxygen availability by increasing red blood cell productions, decreasing the binding capacity of haemoglobin and by increasing breathing rate.) Many tribes live in the high altitude of Himalyas have a higher red blood cell than people living in the plains. The tribes are adapted genetically to such high altitude condition.

(c) **Behaviour Adaptations -** Suspension
Hibernation (Winter sleep) – Winter sleep or period of dormancy
Cold blooded animals – ***e.g.*** Amphibians, reptiles
Hot blooded animals – ***e.g.*** Polar bear, North ground squirrels
Aestivation (Summer sleep) – Escape from heat of sun
e.g. Lung fishes, Snails, Ground squirrels in south-west desert
Diapause – Under unfavourable conditions many zooplankton species in lakes and ponds are known to enter diapause, a stage of suspended development.

Some examples of migration (behavioural adaptation)

Type of migration	Examples	Activities
Long-distance	Arctic tern	• Nests close to north pole in summer. Flies from North (Arctic) to Antarctica in autumn and returns to North pole again each spring.
Short-distance place.	Caribou, Elk and whale	• Migrates in search of food each winter to warmer place.
Periodic	Locust (Tiddi)	• Large population migrate in search of feeding grounds.

Note : Thermal Migration – Thermal migration has been seen in birds (siberian cranes, arctic tern), mammals (Bison, caribou), fishes (salmon) etc.
Some organisms show behavioural responses to cope with variations in their environment. Mammals have to deal with the high temperatures of their habitat, but manage to keep their body temperature fairly constant by behavioural means. **Desert lizards** lack the physiological ability. They bask in the sun and absorb heat when their body temperature drops below the comfort zone, but move into shade when the ambient temperature starts increasing. Some species are capable of burrowing into the soil to hide and escape from the above-ground heat.

(ii) **Response to abiotic factors :**
A few organisms can tolerate and thrive in a wide range of temperatures (they are called **eurythermal**), but, a vast majority of them are restricted to a narrow range of temperatures (such organisms are called **stenothermal**). The levels of thermal tolerance of different species determine to a large extent their geographical distribution.

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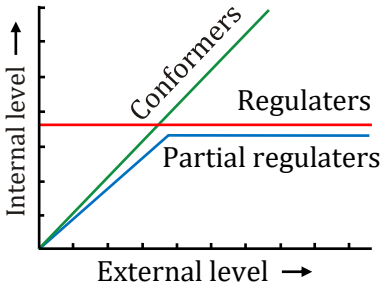
Regulaters :

Some organisms are able to maintain homeostasis by physiological (sometimes behavioural also) means which ensures constant body temperature, constant osmotic concentration, etc. All birds and mammals, and a very few lower vertebrate and invertebrate species are indeed capable of such regulation (thermoregulation and osmoregulation). **Evolutionary biologists believe that the 'success' of mammals is largely due to their ability to maintain a constant body temperature** and thrive whether they live in Antarctica or in the Sahara desert.



Diagrammatic representation of organismic response

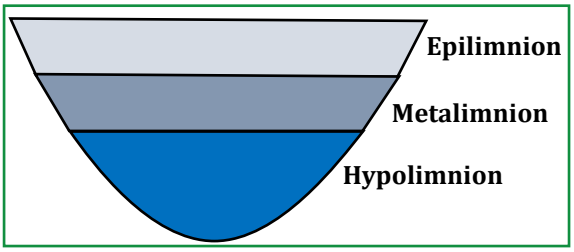
The mechanisms used by most mammals to regulate their body temperature are similar to the ones that we humans use. We maintain a constant body temperature of 37°C. In summer, when outside temperature is more than our body temperature, we sweat profusely. The resulting evaporative cooling, similar to what happens with a desert cooler in operation, brings down the body temperature. In winter when the temperature is much lower than 37°C, we start to shiver, a kind of exercise which produces heat and raises the body temperature. Plants, on the other hand, do not have such mechanisms to maintain internal temperatures.

Conformers : Organism who cannot maintain a constant internal environment means their body temperature or osmotic concentration change with external environment.

An overwhelming **majority (99 per cent) of animals** and nearly all plants cannot maintain a constant internal environment. Their body temperature changes with the ambient (atmospheric) temperature. In aquatic animals, the osmotic concentration of the body fluids change with that of the ambient (surrounding) water osmotic concentration. These animals and plants are simply conformers.

Considering the benefits of a constant internal environment to the organism, we must ask why these conformers had not evolved to become regulators. Recall the human analogy we used above; much as they like, how many people can really afford an air conditioner? Many simply 'sweat it out' and resign themselves to suboptimal performance in hot summer months. **Thermoregulation is energetically expensive for many organisms.** This is particularly true for small animals like shrews and humming birds.

(iii) Thermal stratification in lakes :-



Thermal stratification occurs in deep water body because of difference in temperature of water at different depth. Mainly three layer or zone occurs in lake below (like in summer)

Epilimnion – The top layer gains warmth.

Metalimnion/thermocline – Middle region steady decline in temperature or a gradual change in temperature.

Hypolimnion – Bottom which is not affected by temperature.

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(K) Soil or Edaphic Factor :

- Soil is the uppermost layer of earths crust formed by weathering of rocks. It is the mixture of living or non-living materials.
- The nature and properties of soil in different places vary; it is dependent on the climate, the weathering process, whether soil is transported or sedimentary and how soil development occurred. Various characteristics of the soil such as soil composition, grain size and aggregation determine the percolation and water holding capacity of the soils. These characteristics along with parameters such as pH, mineral composition and topography determine to a large extent the vegetation in any area. This in turn dictates the type of animals that can be supported. Similarly, in the aquatic environment, the sediment-characteristics often determine the type of benthic animals that can thrive there.

Minerals 45% + **Water 25%** + **Air 25%** + **Organic matter** (living + non-living) **5%**
Soil formation is slow process 1-inch soil is formed in 500-1000 years
Pedogenesis – development of soil or soil formation
Pedology (Edaphology) – study of soil

(i) Soil mineral matter – As a result of weathering the mineral particles of different size are formed.

Soil Type	Size of particles
Clay	less than 0.002 mm
Silt	0.002 – 0.02 mm
Fine sand	0.02 – 0.20
Coarse sand	0.20 – 2.0
Gravel or Grit	2mm – 5mm
Coarse Gravel	Above 5.00

Sandy Soil	=	85% sand + 15% clay or silt or both
Loamy Soil	=	50% sand + 50% clay or silt or both
Silt Soil	=	90% silt + 10% sand

Note : Loam Soil is the **best soil** for growing of crops due to high water holding capacity, high aeration and high root penetration.

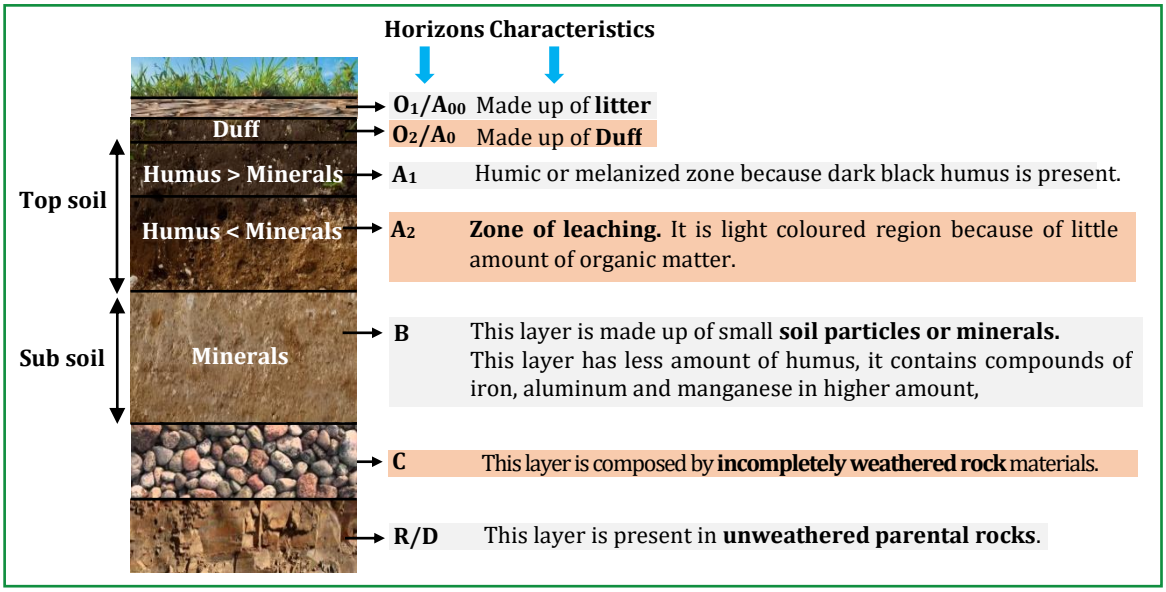
(ii) Soil organic matter— The dead organic matter present in soil is called humus, which is formed by decomposition of plant and animal remains. Freshly fallen plant and animal material called detritus or **litter**, partially decomposed litter is called **duff**. Fully decomposed litter is called **humus**.

Litter → Duff → Humus

Decomposition (Formation of Humus) :

- Decomposers break down complex organic matter into simple organic matter (humus) and inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition. Dead plant remains such as leaves, bark, flowers and dead remains of animals, including fecal matter, constitute detritus, which is the raw material for decomposition. The important steps in the process of decomposition are **fragmentation, leaching, catabolism, humification and mineralisation**.
- **Detritivores (*e.g.* earthworm)** break down detritus into smaller particles. This process is called fragmentation. By the process of leaching, water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts. Bacterial and fungal enzymes degrade detritus into simple organic and inorganic substances, This process is called as **catabolism**.
- It is important to note that all the above steps in decomposition operate simultaneously on the detritus. **Humification and mineralisation** occur during decomposition in the soil. Humification leads to accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. Being colloidal in nature it serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as **mineralisation**.
- Decomposition is largely an **oxygen-requiring** process. The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition, decomposition rate is slower if detritus is rich in lignin and chitin, and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars. **Temperature** and **soil moisture** are the most important climatic factors that regulate decomposition though their effects on the activities of soil microbes. Warm and moist environment favour decomposition whereas low temperature and an anaerobiosis inhibit decomposition resulting in build-up of organic materials.

(iii) Soil profile


Horizons Characteristics
Duff
Humus > Minerals
Humus < Minerals
Minerals
Top soil
Sub soil
O1/A00 Made up of litter
O2/A0 Made up of Duff
A1 Humic or melanized zone because dark black humus is present.
A2 Zone of leaching. It is light coloured region because of little amount of organic matter.
B This layer is made up of small soil particles or minerals. This layer has less amount of humus, it contains compounds of iron, aluminum and manganese in higher amount,
C This layer is composed by incompletely weathered rock materials.
R/D This layer is present in unweathered parental rocks.

Note : **Best pH** of the soil for cultivation of plant is **5.5 – 6.5**
Excess irrigation produce **water logging** and **salinity** in soil.

(L) Water :

Next to temperature, water is the most important factor influencing the life of organisms. You might think that organisms living in oceans, lakes and rivers should not face any water-related problems, but it is not true. For aquatic organisms the quality (chemical composition, pH) of water becomes important. The salt concentration (measured as salinity in parts per thousand), is less than **5 PPT** in inland waters, **30-35 PPT** the sea and more then **100 PPT** in some hypersaline lagoons. Some organisms are tolerant of a wide range of salinities (**euryhaline**) but others are restricted to a narrow range (**stenohaline**). Many freshwater animals cannot live for long in sea water and vice versa because of the osmotic problems, they would face.

(M) Topography :

It includes the physical features of the earth like altitude, slope, exposure, mountain chains valleys plants. It affects distribution of organism by influencing the climatic factor like light, wind, rainfall etc.

★ Golden Key Points ★

- Geographical distribution of different species is determined by the level of thermal tolerance.
- The availability of light on land is closely linked with temperature since the sun is the source of for both.
- In aquatic environment, the sediment characteristics often determine the type of benthic animals that can thrive there.
- Under unfavourable conditions many zooplankton species in lakes and pond are known to enter diapause, a stage of suspended development.

BEGINNER'S BOX-2

ABIOTC COMPONENT OF ECOSYSTEM AND ADAPTATIONS IN ORGANISMS

1. A majority of organisms which are restricted to a narrow range of temperature are called as :
(1) Stenothermal (2) Endothermal
(3) Homeothermal (4) Eurythermal

2. Percolation and water holding capacity of soil is dependent upon :
(1) Soil composition (2) Grain size (3) Aggregation (4) All of these

3. Which of the following is not the stage of suspension?
(1) Migration (2) Hibernation
(3) Aestivation (4) Diapause

4. Seals have a thick layer of fat (blubber) below their skin that act as an :
(1) Thermostat (2) Capacitor (3) Resistor (4) Insulator

5. The salinity in sea water in parts per thousand (ppt) ranges between :
(1) 5–15 (2) 30–35 (3) 50–75 (4) More than 100

6. To avoid summer related problems such as heat and dessication fish undergoes :
(1) Hibernation (2) Diapause (3) Aestivation (4) Dormancy

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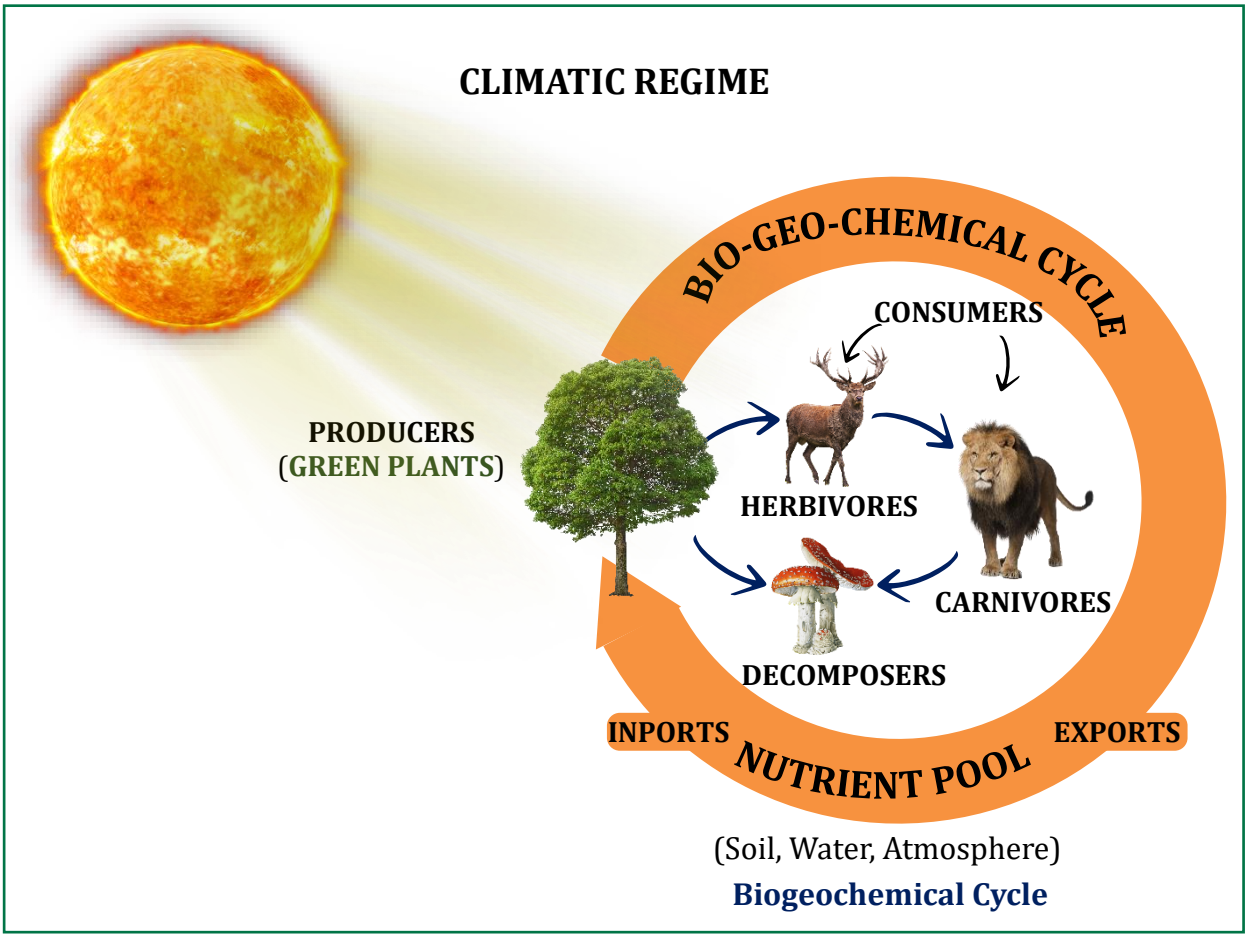
(N) Bio-Geo Chemical Cycle or Nutrient Cycle :

Bio	–	Living organism
Geo	–	Rock, Soil, Air, Water
Chemical	–	Mineral or Nutrients
Cycle	–	Path

All the types of material required by ecosystem in addition of energy, are available continuously to system through recycling. Thus there is a constant exchange of materials between the living organism and their abiotic environment through the recyling of materials. This is called Bio-geo chemical cycle.

Environmental factors, *e.g.*, soil, moisture, pH, temperature etc., regulate the rate of release of nutrients into the atmosphere.



Biogeochemical Cycle

The reservoir function is to fulfill the deficit in biogeochemical cycle created by imbalance between Influx and efflux.

Types of nutrient cycles are found in an ecosystem :

Gaseous Cycle – C, H, N, O cycles. Reservoir is in the atmosphere (air) or in Hydrosphere (water).

Sedimentary cycle – P, S, Ca cycles reservoirs are in earth's crust (lithosphere)

Note : In these cycles, the bulk material remains in the inactive reservoir on earth crust like sediment of sea, or water bodies.

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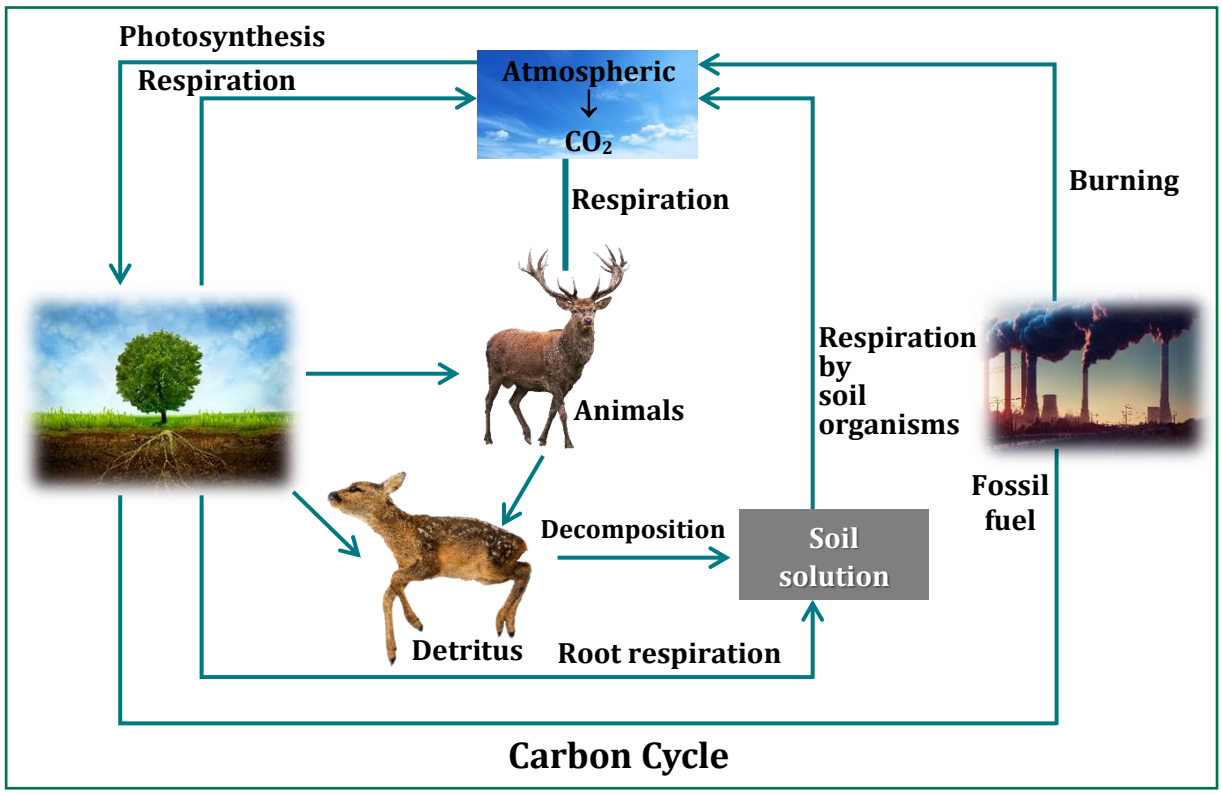
(i) Gaseous Cycle

Carbon Cycle :-

Main reservoir of carbon are **atmosphere, Ocean, Carbonate, Rocks, Coal** and **Petroleum.** The carbon released from them is present in the atmosphere in the form of carbondioxide. Carbon is present in every organic component of organism. The green autotrophs utilize CO_2 from the air to synthesize food materials which is obtained by other organisms as food. Carnivores obtain their carbonic food from the herbivores. These carbonic matter produce CO_2 through the oxidation or respiration which dissolve in air or water and again utilized by the plants.



Carbon Cycle

Carbon constitutes **49%** of **dry weight** of organisms and is next only to water. Atmosphere only contains about **1%** of total global carbon.

If we look at the total quantity of global carbon, we find that **71 per cent** carbon is found dissolved in oceans. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere.

Carbon cycling occurs through atmosphere, ocean and through living and dead organisms.

According to one estimate **4×10^{13} kg** of carbon is fixed in the biosphere through photosynthesis annually.

(ii) Sedimentary Cycle

Phosphorus cycle :-

Main source of phosphorus is **rocks**. It comes from the weathering of phosphorus containing rock in the soil. Plants absorb this phosphrous from the soil and transfer this phosphate to animals and after the death of animals it is released again into the lithosphere by the action of decomposers (Phosphate-solubilising bacteria). Phosphorus is the main constituent of protoplasm, plasma membrane, bones and teeth.

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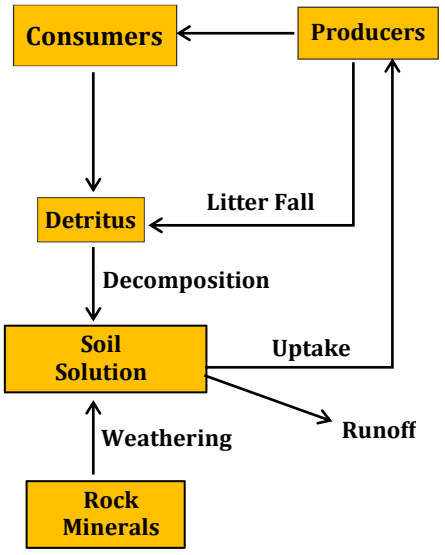
Sometimes some of the elements like phosphorus and calcium reach into the sea through water, from where they transform into rocks. They separate from the cycle for a long time so it is also known as **sedimentary cycle**.

But when these rocks break after sometime then this phosphorus is again made available to the sea plant or sea weeds, which pass into fish and sea birds. The excretory materials of birds on the rocks of sea shore is called **Guano** and it is a source of phosphorus.

Note : Plants absorb phosphate from the soil in the form of orthophosphate (PO_4^{3-})

Difference between Carbon and Phosphorus cycle

- Atmospheric inputs of phosphorus through rainfall are much smaller than carbon.
- Gaseous exchanges of phosphorus between organism and environment are negligible.



A simplified model of phosphorus cycling in a terrestrial ecosystem

Ecosystem Services :-

Healthy ecosystems are the base for a wide range of economic, environmental and aesthetic goods and services. The products of ecosystem processes are named as **Ecosystem services**, for **example**, healthy forest ecosystems purify air and water, mitigate (minimise) droughts and floods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values. Though value of such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a **hefty (bulk) price tag**.

Robert Constanza and his colleagues have very recently tried to put price tags on nature's life-support services. Reserchers have put an average price tag of **US $ 33 trillion** a year on these fundamental ecosystems services, which are largely taken for granted because they are free. This is nearly twice the value of the global gross national product GNP which is **(US $ 18 trillion).** Out of the total cost of various ecosystem services, **the soil formation accounts for about 50 percent, and contributions of other services like recreation and nutrient cycling, are less than 10 percent each. The cost of climate regulation and habitat for wildlife are about 6 percent each.**

3. Terrestrial Biomes :

- Large ecosystem is called biome. Mainly large aquatic and terrestrial ecosystem are called biomes.
- In each biome climax community is uniform and each biome is identified by its climax community.
- Altitude and latitude determine the boundary of biome.
- Regional and local variations within each biome lead to the formation of a wide variety of habitats.

(A) Biome Distribution :

(i) Altitude :

Height above the sea surface of any place.

The temperature and species diversity decreases on increasing altitude.

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(ii) Latitude :

The distance of any place from the equator

The temperature, light intensity and species diversity are maximum at the equator and decreases gradually towards the pole.

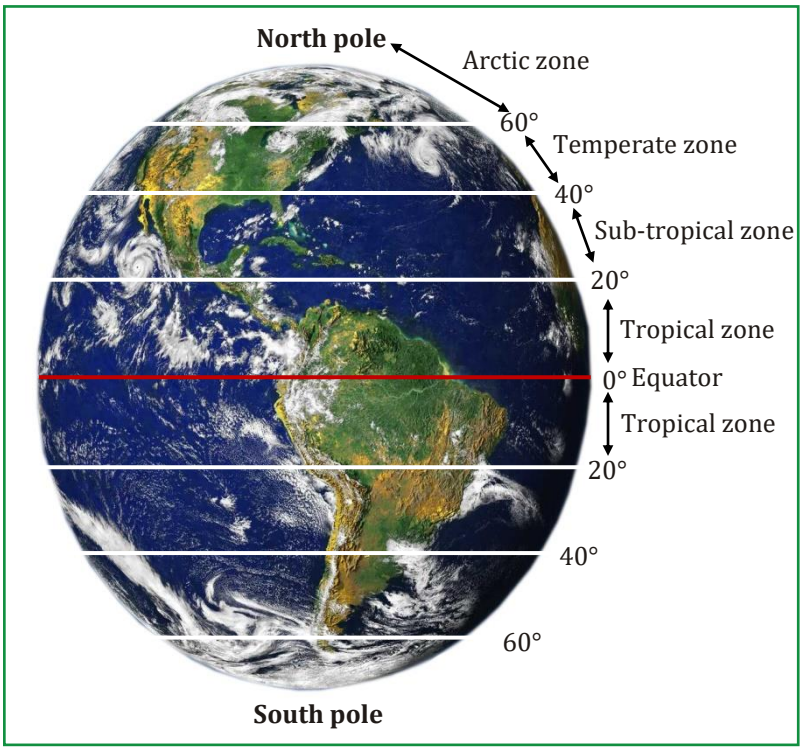
On the basis of variation in mean temperature along latitude the main climatic regions are–

Tropical = 0^0 – 20^0 latitude

Subtropical = 20^0 – 40^0 latitude

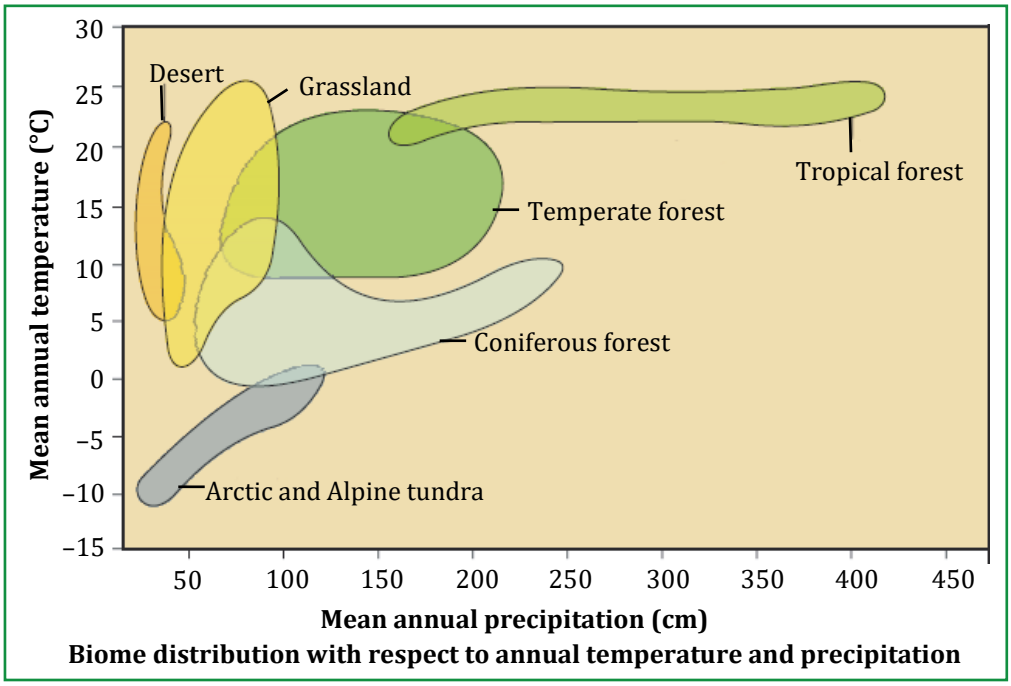
Temperate = 40^0 – 60^0 latitud

Arctic and antarctic = 60^0 – 80^0 latitude



Note : Effect of altitude and latitude are almost same on temperature.

The types of vegetation from sea level to measuring altitudes are similar to increasing latitude (distance from equator)



Biome distribution with respect to annual temperature and precipitation

TAKE THIS FROM ORGANISMS AND POPULATIONS

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(B) Types of Biome :

	Biome	Latitude	Altitude	Vegetation
1.	Tundra (fragile-biome)	Above 60° North	3600 meter height of Himalaya	**Lichen, Moss, Grass** **Note :** This biome is tree less and also known as arctic desert or alpine tundra Timber line – Line beyond which trees are not found. Perma frost – In this region soil is covered by snow or ice.
2.	Northern coniferous or Needle leaf or temperate forest	40° – 60°	1700 to 3000 meter	**Pine (Pinus), Deodar (Cedrus), Cypress (Cupressus torulosa), Spruce (Picea smithiana), Silverfir (Abies pindrow)** **Note :** Coniferous forest posses needle like leaves This forest also known as Taiga or North wood.
3.	Temperate decidous or broad leaf forest	40°– 60°	1500 to 2400 meter	**Oak (Quercus)** **Note :** Trees shed their leaves in autumn and bear again in spring
4.	Tropical deciduous forest	Occurs widely in the Northern and Southern part of our country in plain and low hilly area.		**Sal (Shorea robusta), Teak (Tectona grandis),** **Tendu, Chiraungi, Khair** **Note :** Leaves of most of the tree fall before summer.
5.	Tropical rain forest	Tropical rain forest are found at equatorial region around the earth. In India tropical rain forest are distributed mainly along western Ghats and Eastern Himalya (Assam, W. Bengal, Andman, Manipur)		**Dipterocarpus and Hopea are most common tree species in India.** **Lianas are also found.**
6.	Chaparral (Mediterranean) scrub forest	These forest are **found pacific coast of North America and South coast of Australia**		Draught resistant and fire resistant plant species are found **e.g.** Small tree, Shrub (sage)
7.	Tropical Savanna biome (Thorn forest)	Tropical Savanna biome are found in South America and Australia.		**Coarse grass – Dichanthium, Sechima, Phragmites** **Trees – Acacia, Eucalyptus, Zizyphus, Capparis** **Note :** In this biome grass are found with scattered tree. This biome also known as tropical grass land

<table>
<tr><td>8.</td><td>Grass land biome</td><td>Name of Grass lands</td><td>Place</td><td></td></tr>
<tr><td></td><td></td><td>Prairies</td><td>North America</td><td></td></tr>
<tr><td></td><td></td><td>Pampas</td><td>South America</td><td></td></tr>
<tr><td></td><td></td><td>Steppes</td><td>Europe and Asia (Russia)</td><td></td></tr>
<tr><td></td><td></td><td>Tussocks</td><td>Newzealand</td><td></td></tr>
<tr><td></td><td></td><td>Veldts</td><td>Africa</td><td></td></tr>
<tr><td>9.</td><td>Desert Biome</td><td>Name of desert</td><td>Place/Area</td><td></td></tr>
<tr><td></td><td></td><td>Sahara</td><td>North Africa</td><td></td></tr>
<tr><td></td><td></td><td>Tibbet, Gobi, Thar</td><td>Asia</td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Note : Gobi desert is cold desert Sahara and Thar are hot desert</td><td></td></tr>
</table>

What is so special about tropics that might account for their greater biological diversity?

Ecologists and evolutionary biologists have proposed various hypotheses; some important ones are–

(a) Speciation is generally a function of time, unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes have remained relatively undisturbed for millions of years and thus, had a long. evolutionary time for species diversification,

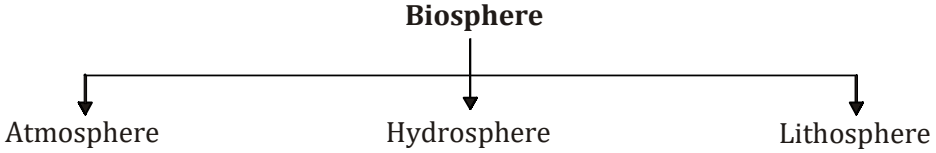
(b) Tropical environments, unlike temperate ones, are less seasonal, relatively more constant and predictable. Such constant environments promote niche specialisation and lead to a greater species diversity and

(c) There is more solar energy available in the tropics, which contributes to higher productivity; this in turn might contribute indirectly to greater diversity.

Note : In temperate deciduos forest soils, the top horizon of soil is a rich mixuture of humus (nutrient) and inorganic components but top soil of tropical rain forest is nutrient poor and shallow due to heavy rainfall.

4. Biosphere :

- All the living and non-living thing (Biotic + Abiotic) of the earth (biomes) combine together to constitute a big ecosystem called Biosphere. Biosphere is also called Ecosphere.



(A) Lithosphere : The living components and non-living components present on the earth surface consititutes the litho sphere.

(B) Hydrosphere : All living components and non-living components present in water constitutes the hydrosphere.

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(C) Atmosphere : All living components and non-living components of air constitutes the atmosphere.

Note : Biosphere (space ship or earth) is a closed system for minerals and biosphere is an open system in regards with the energy.

★ Golden Key Points ★

- The formation of biome is mainly decided by two abiotic factor temperature and precipitation.
- Upper soil of temperate deciduous forest is more fertile than tropical rain forest.

BEGINNER'S BOX-3 NUTRIENT CYCLE, BIOME AND BIOSPHERE

1. Which is known as flora and fauna rich biome?
(1) Temperate deciduous (2) Tropical rain forest
(3) Desert (4) Alpine

2. Which biome is specialised by thick covering of snow year to year?
(1) Tropical rain forest (2) Tundra biome
(3) Taiga biome (4) Grassland

3. Savana biome is characterised by:
(1) Only grasses (2) Grasses with scattered trees
(3) Broad leaf trees (4) All of the above

4. Which is not a reservoir for phosphorous in phosphorous cycle?
(1) Atmosphere (2) Lithosphere
(3) Hydrosphere (4) All of the above

BEGINNER'S BOX ANSWERS KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6	7	8
	Ans.	2	4	2	2	1	3	2	3

BEGINNER'S BOX-2	Que.	1	2	3	4	5	6
	Ans.	1	4	1	4	2	3

BEGINNER'S BOX-3	Que.	1	2	3	4
	Ans.	2	2	2	1

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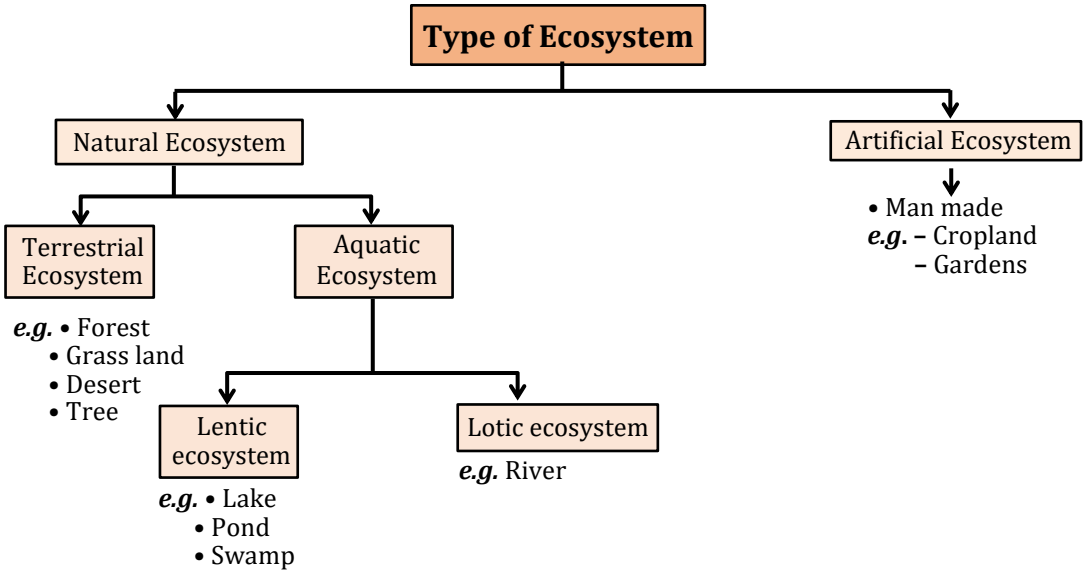
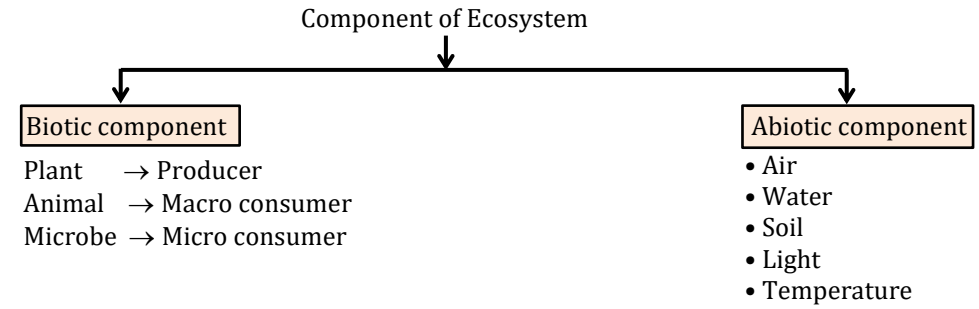
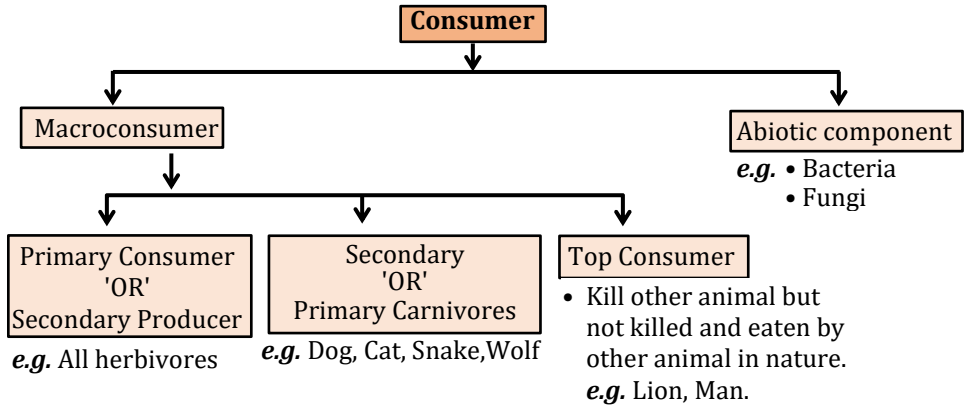
ESSENCE







Functional Aspects of ecosystem.

(i) Energy Flow
(ii) Nutrient cycling
(iii) Productivity
(iv) Decomposition

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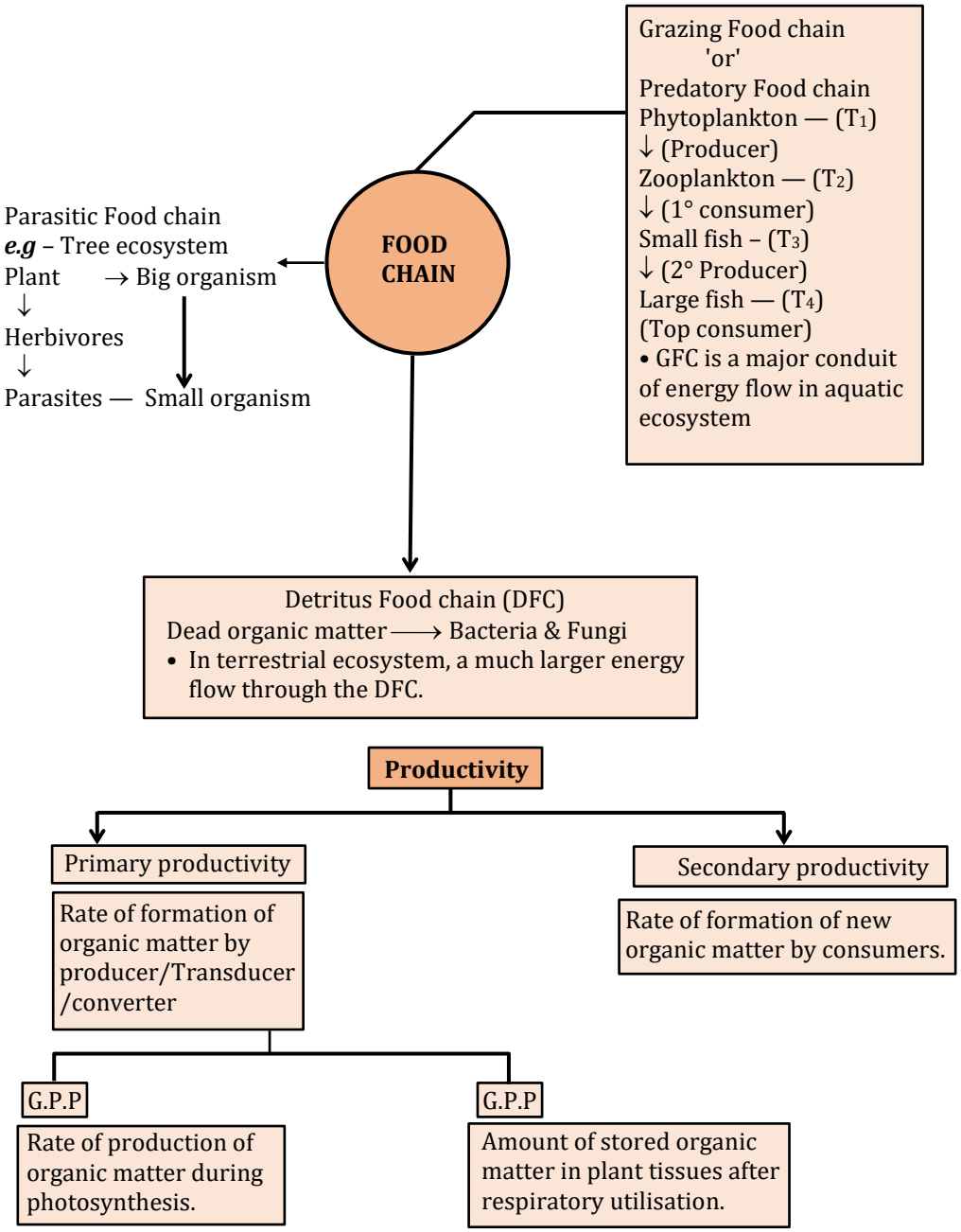
FOOD CHAIN
Grazing Food chain
'or'
Predatory Food chain
Phytoplankton — (T1)
↓ (Producer)
Zooplankton — (T2)
↓ (1° consumer)
Small fish – (T3)
↓ (2° Producer)
Large fish — (T4)
(Top consumer)
• GFC is a major conduit of energy flow in aquatic ecosystem
Parasitic Food chain
e.g – Tree ecosystem
Plant → Big organism
↓
Herbivores
↓
Parasites — Small organism
Detritus Food chain (DFC)
Dead organic matter ⟶ Bacteria & Fungi
• In terrestrial ecosystem, a much larger energy flow through the DFC.
Productivity
Primary productivity
Rate of formation of organic matter by producer/Transducer /converter
Secondary productivity
Rate of formation of new organic matter by consumers.
G.P.P
Rate of production of organic matter during photosynthesis.
G.P.P
Amount of stored organic matter in plant tissues after respiratory utilisation.

Factors affecting Productivity

(a) Area

(b) Climate — light, Temperature, Rainfall

(c) Soil ⟶ Amount of nutrients

(d) Photosynthetic capacity.

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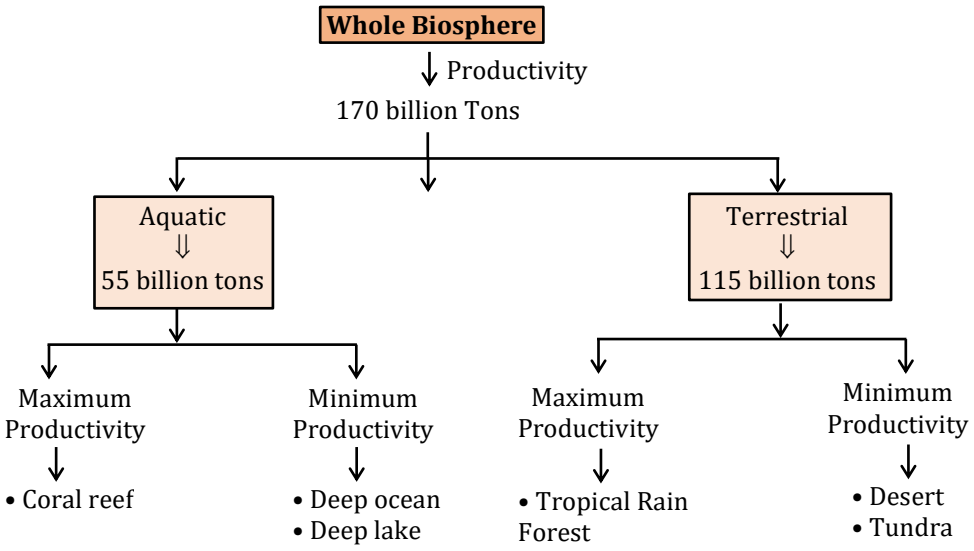
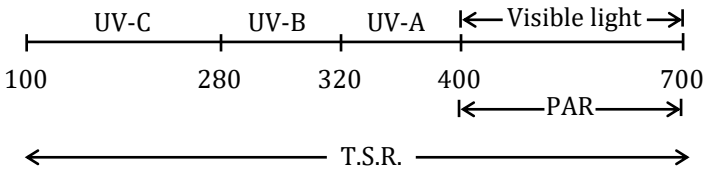


Light :-



- UV–C → most lethal.
- UV–B → most harmful for organism.

Albido value :-

- Fresh snow – 80 %
- Sand – 20 – 30 %
- Forest – 5 – 10%

Temperature :-

- Heat loss or heat gain is a function of surface area.

Allen's Rule :-

Cold climate ⟶ Limbs, ears ⟶ short ⟶ less body heat liberated

Warm climate ⟶ Limbs, ears ⟶ Long ⟶ more body heat liberated.

- Temperature is the most ecologically relevant environmental factor.
- Equator ⟶ Pole – temperature decreases.
- Plains ⟶ Mountains – temperature decreases.

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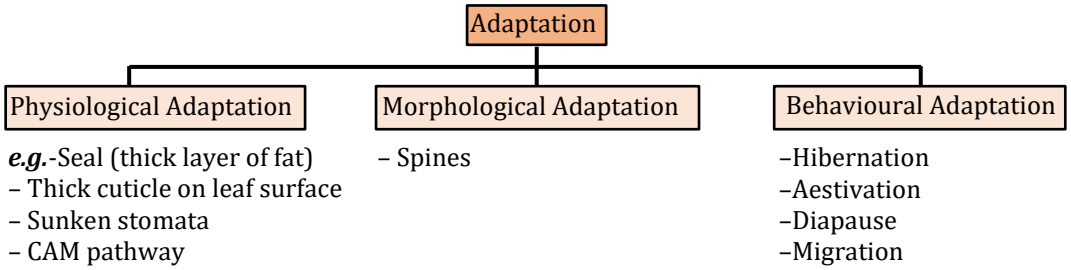

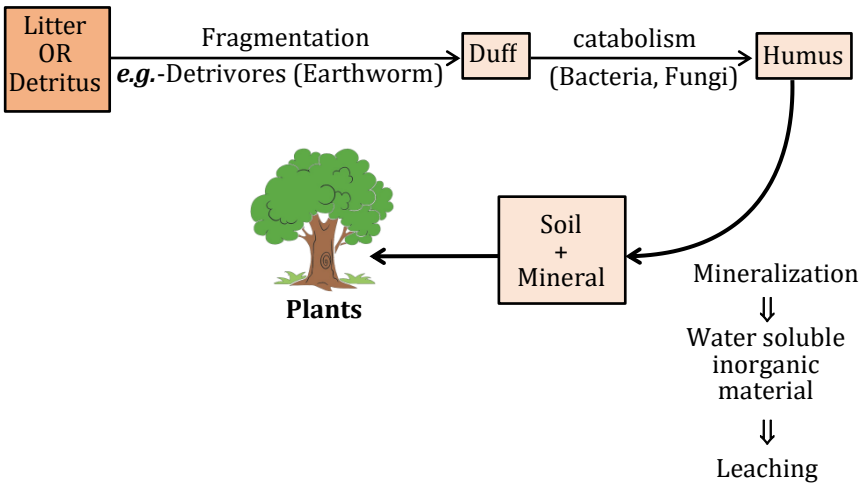

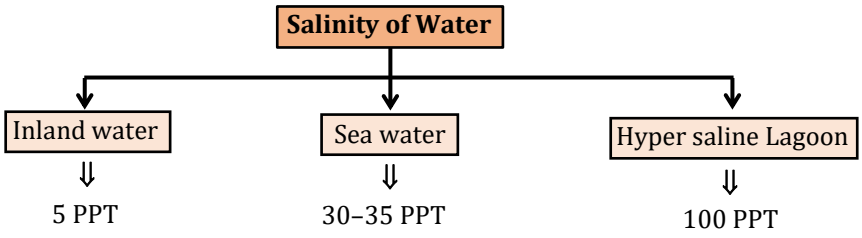

Euryhaline ⟶ ***e.g.*** – Moll fish

Stenohaline ⟶ ***e.g.*** – Gold Fish

Carbon cycle :-

- 0.03 % CO_2 in atmosphere
- ≈49% of dry weight
- ≈ 71% of dissolve carbon in ocean
- Annually ⟶ 4×10^{13} kg carbon ⟶ Fixed by Photosynthesis in Biosphere.

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